DURABILITY OF FRP STRENGTHENED CONCRETE STRUCTURES

Adel Hammami[1,aa], Abdullah Alshamsi[2] and Saeed Hareeb[1]

1. Department of Mechanical Engineering, 2. Department of Civil Engineering
College of Engineering, United Arab Emirates University,
P.O. Box 17555, Al-Ain, United Arab Emirates

ABSTRACT

Conventional rehabilitating and strengthening techniques using stitching and steel reinforcing patch design provide a promising strengthening solution in structural concrete applications. However, the weight penalty, labor-intensive application, and subsequent corrosion of the steel material may eventually increase the overall maintenance cost on the long run. Accordingly, this drives the development and application of new materials and technologies, which extend the service life of many structures, such as strengthening of structures to carry greater traffic loads, to cope with change of use, to rectify design faults, and for repair. One class of materials that is meeting these challenges is fiber reinforced composite materials (FRC), their use is becoming increasingly important for extending the service life of civil infrastructures. The attractive benefits of using FRP in real life civil concrete application include its strength to weight ratio, its resistance to corrosion, and its ease of molding into complex shapes without increasing manufacturing costs. However, some issues regarding the performance of these materials under severe environmental conditions need further investigations, especially when it comes to high temperature and variable moisture conditions. In this paper, reinforced concrete beams strengthened with three types of composite materials were exposed to different environmental conditions then their performance will be compared to that of virgin specimens.

INTRODUCTION

The use of high-performance construction materials and systems has been pinpointed as key to developing the infrastructure for the twenty-first century. The use of advanced materials, including high-performance concretes, high performance steels, and composites, is viewed as a mean to developing superior, yet cost effective structural performance over the life time of a structure. These systems show the potential for substantial savings for reasons including the following:

1. increased and enhanced rehabilitation strategies
2. reduced maintenance costs over the structure's lifetime
3. longer lasting structures, less susceptible to environmental degradation
4. use of higher and less specialized equipment for on-site erection (due to lower weight potential)

Bonding of a fiber-reinforced polymer to the tension face of a beam has become a popular flexural strengthening method in recent years. As a result, a large number of studies have been carried out in the last decade on the behavior of these FRP-strengthened beams. Many of these studies reported premature failures by debonding of the FRP plate with or without the concrete cover attached. The most commonly reported debonding failure occurs at or near the plate end, by either separation of the concrete cover or interfacial debonding of the FRP plate from the RC beam.

A comprehensive review of existing plate debonding strength models was presented by Smith and Teng [1,2]. Each model was summarized and classified into one of three

[a] To whom correspondence should be addressed.

categories based on the approach taken, and its theoretical basis clarified. A schematic representation of the six main failure modes observed in tests is shown in Figure 1. These are herein termed (a) flexural failure by FRP rupture, (b) flexural failure by crushing of compressive concrete, (c) shear failure, (d) concrete cover separation, (e) plate end interfacial debonding, and (f) intermediate crack induced interfacial debonding. Of the two plates end debonding failure modes, failure by separation of the concrete cover has been far more commonly reported. It is generally believed that failure of the concrete cover is initiated by the formation of a crack at or near the plate end, due to high interfacial shear and normal stresses caused by the abrupt termination of the plate. As both plate end debonding failure modes are due to the same cause, i.e., high interfacial shear and normal stresses near the plate end, plate end debonding has not been differentiated from concrete cover separation in many of the existing plate end debonding strength models.

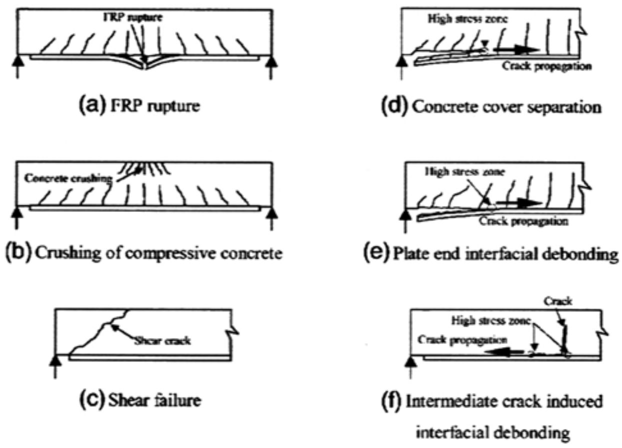

Figure 1. Failure modes of FRP-strengthened RC beams, (a) FRP rupture; (b) Crushing of compressive concrete; (c) Shear failure; (d) Concrete cover separation; (e) Plate end interfacial debonding; (f) Intermediate crack induced interfacial debonding [1].

When reviewing some of the published work, it appears that most of the research performed was addressing mainly the strengthening issues, i.e, short term performance. While the durability and long term performance of the material being used is not well covered especially when dealing with hot climate. Through this work, it is anticipated to provide some understanding on the effect of harsh climatic conditions on the performance of these materials. It is well known that glass transition temperature of the resin is a key parameter that affects its physical and mechanical properties. Commonly used resins for strengthening have a T_g close to 60 ºC. Daytime temperature in the region is sometimes exceeding the resin glass transition temperature. Consequently monitoring the durability of these materials is crucial towards their successful use as strengthening and repair materials.

REFERENCES

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